FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE

PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
BERKELEY, CALIFORNIA

RESEARCH NOTE

No. 171 November 1960

EROSION FROM MOUNTAIN SIDE SLOPES AFTER FIRE IN SOUTHERN CALIFORNIA

By

Jay S. Krammes, Research Forester

The night of July 21, 1960 was a hectic one for firefighters setting backfires along the Glendora Mountain Road in a desperate effort to check the Johnstone Fire on the San Dimas Experimental Forest. What made the job so hectic? Not the fire, but dangerous, active erosion! The men had to be continually alert to dodge large rocks rolling downslope only seconds after the fire passed.

These men were witnessing how fast and furiously erosion begins after a southern California brush fire. Less than a week after the Johnstone Fire, so much soil material had moved down the denuded slopes that debris cones often blocked roads and trails (fig. 1).

In most areas, surface runoff of rainfall is the main cause of soil erosion. In the rugged San Gabriel Mountains, however, we are faced with a two-fold erosion problem: winter scour from surface runoff plus "dry creep" from steep side slopes during the summer. 1/ Fire's destruction of the plant cover greatly accelerates these processes. Until recently no one had a good opportunity to measure dry creep following a fire, but the Woodwardia Fire provided the opportunity when it swept over an established erosion study area in the mountains above Los Angeles during October 1959.

1/ Anderson, H. W., G. B. Coleman, and P. W. Zinke. Summer slides and winter scour...dry-wet erosion in southern California mountains. U. S. Forest Serv., Pacific Southwest Forest and Range Expt. Sta., Tech. Paper 36. 12 pp., illus. July 1959.

Figure 1.--Road blocked by slide one week after the Johnstone Fire on the San Dimas Experimental Forest.

Anderson, Coleman, and Zinke had found that under long unburned conditions dry-season debris movement exceeded wet-season movement on most of the study sites. 2/ Their report covered a 5-year period; 4 years of below normal rainfall and 1 year of above average rainfall. This report gives data for an additional 2 years, the second of which followed the Woodwardia Fire, and shows the tremendous acceleration of soil movement from a fire-denuded area.

Field Procedures

Half-round steel troughs connected to the original soil surface by a concrete apron were used to catch the debris moving downslope (fig. 2). Wooden baffles installed at two of the sites to catch bouncing rocks were destroyed by the fire. Consequently, a portion of the first measurements following the burn had to be estimated. Later measurements proved the estimates to be rather conservative. Otherwise, material caught in each trough was removed and weighed, corrected for moisture, and sampled for organic matter and rock content. Troughs along the contour of the slopes ranged in length from 10 to 431 feet.

2/ Anderson, Coleman, and Zinke, *op. cit.*

Figure 2.--Debris trough at Falls Canyon. Collector trough filled with debris from dry season movement. Foot trail below the trough has eroded away since the fire.

Results

Debris production rates for the year before the fire showed generally the same trend as published in the 1959 report. 3/ The steep south rejuvenated slopes 4/ were again the greatest producers. Precipitation during the 1958-59 season was 70 percent of normal. Only one storm caused any appreciable wet-season movement, and the rate of debris movement was about the same as previously reported.

On October 13, 1959, the Woodwardia Fire burned four erosion measurement sites in the Arroyo Seco drainage. Immediately after the fire dry creep changed to rapid dry sliding. Although debris movement varied widely, all sites showed a marked increase in dry-season movement.

The first two measurements after the fire showed that side slope erosion had increased at all sites (table 1). The steep south rejuvenated

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3/ Anderson, Coleman, and Zinke, op. cit.

4/ Rejuvenated slopes are the steep slopes flanking stream channels in which renewed channel downcutting has removed the toe of the slope creating an unstable condition and active erosion is taking place.

slopes were still by far the greatest producers, with a 10-fold increase over an already high pre-fire rate (fig. 3). Total annual production from the south-facing Lower Brown sites was 24.7 tons per acre, of which 21.9 tons per acre (89 percent) of the soil movement came from dry sliding during the first 88 days after the fire.

Table 1.--Seasonal debris movement, south rejuvenated slopes

Season From	Season To (inc.)	Number of days	Lower Brown Site III Dry season	Lower Brown Site III Wet season	Lower Brown Site IV Dry season	Lower Brown Site IV Wet season	Lower Brown Site V Dry season	Lower Brown Site V Wet season	Lower Brown Site III,IV,V Dry season	Lower Brown Site III,IV,V Wet season
			Tons per acre		Tons per acre		Tons per acre		Tons per acre	
Five years before fire			6.104	11.331	5.943	4.568	15.671	1.907	9.601	8.180
4/16/58	12/11/58	238	.479	--	.546	--	.223	--	.482	--
12/12/58	3/5/59	82	--	1.667	--	1.276	--	4.355	--	1.809
3/6/59	6/23/59	111	.157	--	.050	--	.034	--	.078	--
Total pre-fire			6.740	12.998	6.539	5.844	15.928	6.262	10.161	9.989
Tons/Acre/Season			.84	1.86	.82	.83	1.99	.89	1.27	1.42
Tons/Acre/Year			2.70		1.65		2.88		2.69	
After fire										
6/25/59	1/8/60	167	1/ 20.070	--	1/ 82.070	--	1/ 68.970	--	62.510	--
1/9/60	3/21/60	100	--	5.150	--	2/ 6.511	--	1.620	--	5.458
3/22/60	5/23/60	62	2.798	--	4.005	--	1.177	--	3.276	--
Total post-fire			22.868	5.150	86.075	6.511	70.147	1.620	65.786	5.458
Tons/Acre/Season			7.62	2.58	28.69	3.26	23.38	.81	21.93	2.74
Tons/Acre/Year			10.20		28.95		24.19		24.67	

1/ Portion of catch estimated because of fire damage to trough installations.

2/ High rate caused by a large limb falling in the chute.

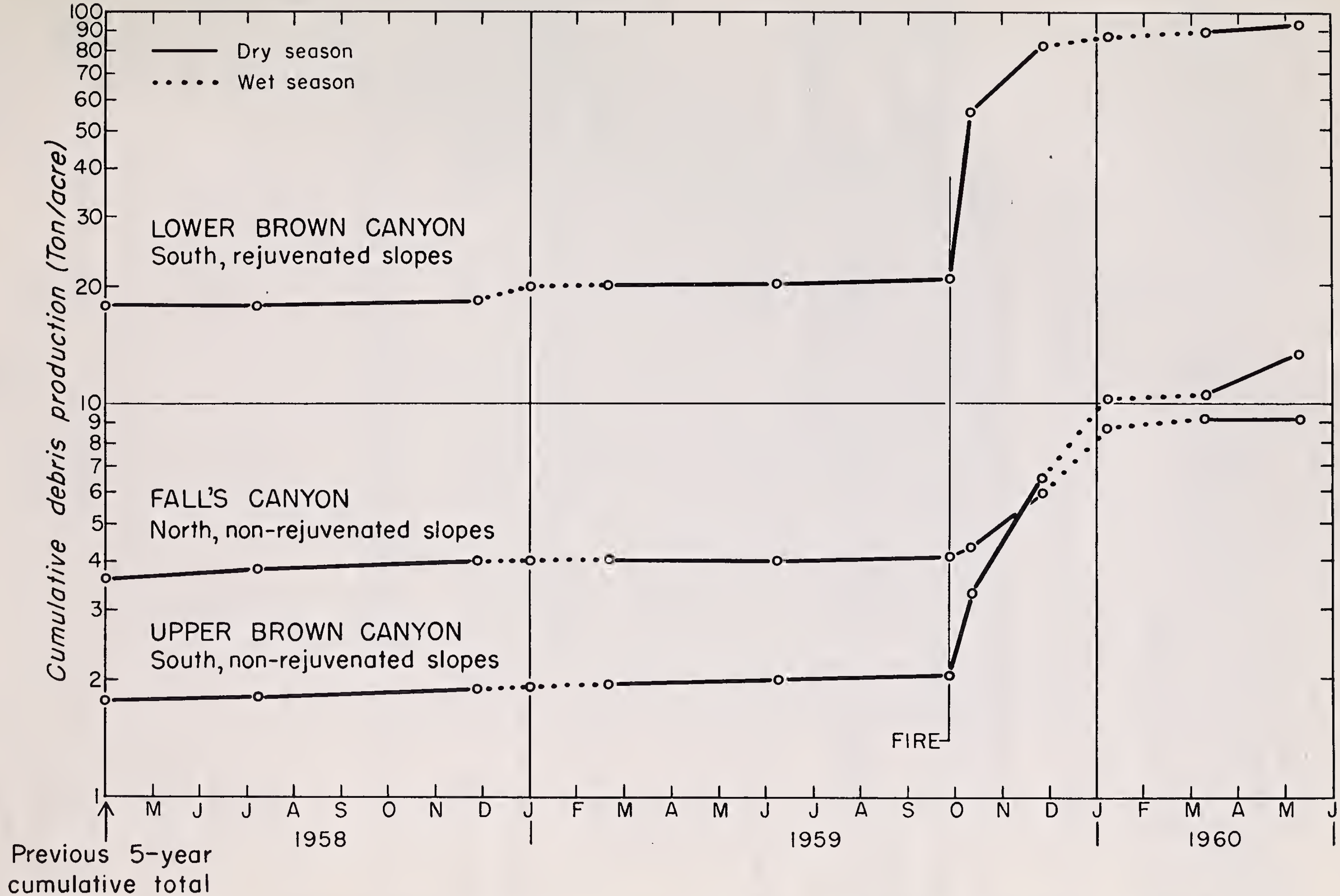

Figure 3.-- Dry and wet-season debris production before and after the Woodwardia Fire.

North rejuvenated slopes showed a post-burn rate of 4.3 tons per acre per year--an increase to about 17 times the unburned average (table 2). Dry-season movement amounted to 3.9 tons per acre or nearly 91 percent of total. Debris production from north non-rejuvenated sites increased 16 times (table 3). The smallest increase of only 4-fold occurred at the south non-rejuvenated site, Upper Brown, where surface rock outcrops served to stabilize the slope somewhat.

Precipitation during the 1959-60 rainy season was 59 percent of normal; consequently post-fire wet-season movement was small.

Table 2.--Seasonal debris movement, north rejuvenated slopes

Season		Number of days	Lower Brown Site I		Lower Brown Site II	
From	To (inc.)		Dry season	Wet season	Dry season	Wet season
			Tons per acre		Tons per acre	
Five years before fire			.660	.642	.675	.544
4/16/58	12/11/58	238	.148	--	.092	--
12/12/58	3/5/59	82	--	.088	--	.130
3/6/59	6/23/59	111	.030	--	.038	--
Total pre-fire			.838	.730	.805	.674
Tons/Acre/Season			.14	.15	.13	.13
Tons/Acre/Year			.26		.26	
After fire						
6/25/59	1/8/60	167	12.299	--	9.926	--
1/9/60	3/21/60	100	--	.983	--	.458
3/22/60	5/23/60	62	.741	--	.719	--
Total post-fire			13.040	.983	10.645	.458
Tons/Acre/Season			4.35	.49	3.55	.23
Tons/Acre/Year			4.84		3.78	

Summary and Conclusions

How much is dry creep erosion increased after the native plant cover is destroyed? Side slope erosion directly related to the Woodwardia Fire ranged from 2.2 to 24.7 tons per acre the first year after the fire. South slopes flanking rejuvenated stream channels yielded the most debris, 10 times the pre-burn rate. Nearly 89 percent of the eroded material came during the dry season.

Table 3.--Seasonal debris movement, nonrejuvenated slopes

Season From	Season To (inc.)	Number of days	Singing Springs South Dry	Singing Springs South Wet	Singing Springs North Dry	Singing Springs North Wet	Upper Brown South Dry	Upper Brown South Wet	Falls North Dry	Falls North Wet
			Tons per acre		Tons per acre		Tons per acre		Tons per acre	
Five years before fire			.518	1.003	.516	.511	2.105	1.500	1.103	.685
4/16/58	12/11/58	138	.102	--	.066	--	.373	--	.121	--
12/12/58	1/15/59	34	.574	--	.149	--	--	.032	--	.028
1/16/59	3/5/59	48	--	.323	--	.196	--	.061	--	.020
3/5/59	6/24/59	111	.017	--	.017	--	.044	--	.044	--
Total pre-fire			1.211	1.326	.748	.707	2.522	1.593	1.268	.733
Tons/Acre/Season			.13	.22	.08	.12	.32	.23	.16	.10
Tons/Acre/Year			.35		.20		.55		.26	
After fire										
6/25/59	12/10/59	167	--	--	--	--	1.846	--	4.519	--
12/11/59	3/21/60	100	--	--	--	--	--	3.067	--	4.053
3/22/60	5/23/60	62	--	--	--	--	.085	--	1.618	--
Total post-fire			--	--	--	--	1.931	3.067	6.137	4.053
Tons/Acre/Season			--	--	--	--	.64	1.53	2.05	2.03
Tons/Acre/Year			--	--	--	--	2.17		4.08	

Other study sites showed similar large increases of 4 to 17 times the pre-fire rates. Dry-season debris movement exceeded wet-season movement at all but one of the study sites. However, precipitation during the period of measurement was below normal, and the few gentle rains gave cohesion to the soil rather than winter scour.

The absence of appreciable winter scour in the first year after the burn does not necessarily decrease debris hazard. The eroded debris remains poised in the stream channels until high flows at some later date carry it destructively to the valley below (fig. 4).

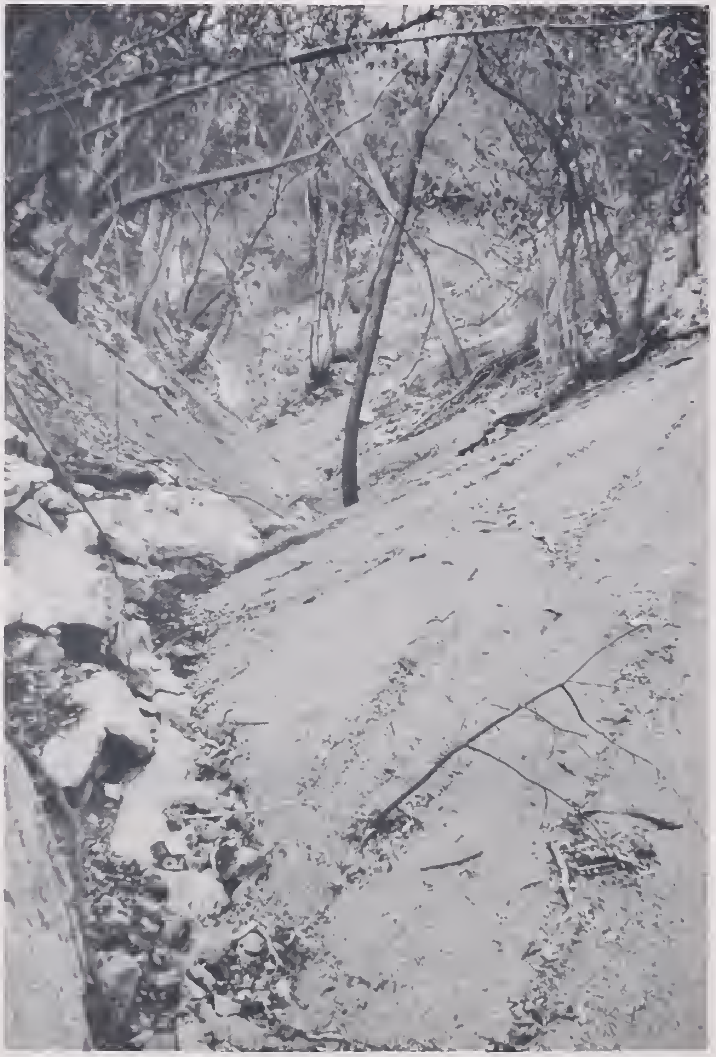

Figure 4.--Lower Brown Canyon. Eroded material perched in the channel bottom which will eventually be flushed from the channel and deposited in debris basins, reservoirs, and property in the valley below.